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RESEARCH ARTICLE

AN EFFICIENT FPGA IMPLEMENTATION OF FEATURE EXTRACTION BASED ON HISTOPATHALOGICAL IMAGE AND SUBSEQUENT CLASSIFICATION BY SVM

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ABSTRACT

This paper present the implementation of feature extraction from histo-pathological images and subsequent classification using Verilog HDL. The proposed automated system use a number of features extracted from images of skin lesions through image processing techniques which consisted of adaptive median filter then applied Gabor filter bank to improve diagnostic accuracy. Histogram equalization to enhance the contrast of the images prior to segmentation is used. The obtained statistics are fed to a support vector machine (SVM) binary classifier to diagnose skin biopsies from patients as either malignant melanoma or benign nevi. Hradware implementation is using Spartan 6 FPGA Kit.

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INTRODUCTION

Many countries in which skin cancer is widely spread in comparison to other types of cancer. Skin cancer costs the health system around $300 million Australian dollar annually, the highest cost of all cancers. The general approach of developing a Computer Aided Diagnostic system for diagnosis of skin cancer is to find the location of a lesion and also to determine an estimate of the probability of a disease. Filters are then very important as pre-processing tools. In order to remove unwanted features, firstly some preprocessing was applied to remove the fine hairs, noise and air bubbles on the skin and facilitating image segmentation by using Gabor Filter and adaptive median filters. The advantage of the median filter is to remove noise without blurring edges. In addition these filters have been shown to possess optimal localization properties in both the spatial and frequency domain and thus are well suited for quality segmentation problems. The Median Filter is one of the best known filters. It replaces the value of the pixel by the median of the intensity values in the neighborhood of that pixel. Segmentation is one of the most widely investigated research areas in pathological image analysis. The Support vector machine (SVM) classier is used widely in bioinformatics, due to its high accuracy, ability to deal with high dimensional data and in this syntax diverse sources of data.

Pre-Processing Stage

This stage includes image resizing, masking, cropping, hair removal, and conversion from RGB colour to intensity grey image. It is meant to facilitate image segmentation by filtering the image and enhancing its important features. In order to remove air bubbles and dermoscopy-gels, adaptive and recursive weighted median filter developed can be utilized. This type of median filter has an edge determined capability.

Median Filter

Median filtering is a nonlinear operation often used in image processing to reduce noise and reserve edges. The median filter considers each pixel in the image in turn and looks at its nearby neighbors to decide whether or not it is representative of its surroundings. It replaces it with the median of those values. The median is calculated by fist sorting all the pixel values from the surrounding neighborhood into numerical order and then replacing the pixel being considered with the middle pixel value [1]. The median filter is a nonlinear digital

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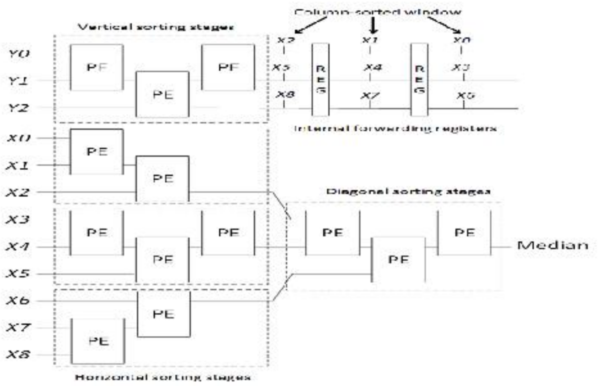
filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing. Median filtering is very widely used in digital image processing because, under certain conditions, it preserves edges while removing noise.



Pipelined median filter architecture

Gabor Filter

The Gabor filter is basically a Gaussian modulated by a complex sinusoid Gabor filters have been used in many applications, such as quality segmentation, target detection, fractal dimension management, document analysis, edge detection, retina identification, image coding and image representation A Gabor filter can be viewed as a sinusoidal plane of particular frequency and orientation, modulated by a Gaussian envelope[1] .It is a linear filter used for edge detection. Frequency and orientation representations of Gabor filters are similar to those of the human visual system, and they have been found to be particularly appropriate for texture representation and discrimination. In the spatial domain, a 2D Gabor filter is a Gaussian kernel function modulated by a sinusoidal plane wave.

Convolution between Image Pixel And Coefficient Kernel

In this chapter it discusses on the method of convolution between coefficient kernels with the image data in the memory. It discusses on the flow of which image data will be convolute with the kernels and the next data to be convolute. This methodology was very important as it will determine on how the control logic unit need to control the flow of the data and the arithmetic process. Figure 4.2 may better explain on the flow of the convolution between image pixel and coefficient kernels. From the figure 4.2, it well explains on how the matrix convolution took place.

Firstly the pixel D11 is convolute with the kernel. The value of D11 after convolution is

D11=(D00xW11)+(D01xW12)+(D02xW13)+(D10xW21)+(D11xW)+(D12xW23)+(D20xW31)+(D21xW32)+(D22xW3).

The next pixel D12=(D01xW11)+(D02xW12)+(D03xW13)+(D11xW21)+(D12xW22)+(D13xW23) +(D21xW31)+(D22xW32)+(D23xW33). The sequence of next pixel to be convolute is shown.

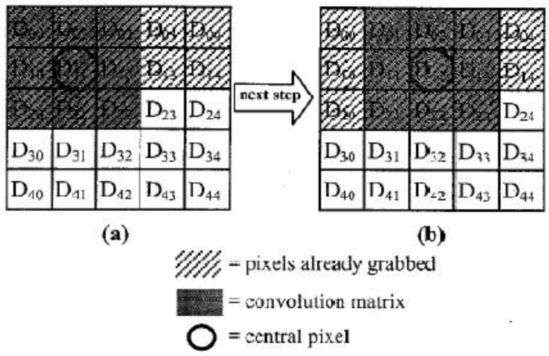


Fig 2 pixel convolution [2]

Method of convolution

Image Processing

Segmentation and classification are important steps in the medical image analyses for radiological evaluation or (CAD). One of the early steps in this stage is image enhancement. The purpose of image enhancement methods is to process a picked image for better contrast and visibility of features of interest for visual examination as well as subsequent computer-aided analysis and diagnoses. Histogram equalization often produces unrealistic effects in photographs; however it is very useful for scientific images like thermal, satellite or x-ray images, often the same class of images to which one would apply false-color. Also histogram equalization can produce undesirable effects (like visible image gradient) when applied to images with low color depth. For example, if applied to 8-bit image displayed with 8-bit gray-scale palette it will further reduce color depth (number of unique shades of gray) of the image. Histogram equalization will work the best when applied to images with much higher color depth than palette size, like continuous data or 16-bit gray-scale images.

$$A = \left(\frac{Cdf(v) - cdf_{\min}}{(M*N) - cdf_{\min}} \right)$$

B = (L - 1)
$H(v)$ = round (A * B)

Image Segmentation

Segmentation is one of the most difficult tasks in image processing. Image segmentation methods can be broadly classified into three categories: 1. Edge-based methods, 2. Pixel-based direct classification methods, 3. Region-based methods .The edge based method is used for segmentation.[1]

The sobel edge operator a 2-D spatial gradient measurement on an image and emphasizes region of high spatial gradient that corresponds to edges. It is used to find the approximate absolute gradient magnitude at each point in an input grey scale. it is differential of two rows or two column , so the element of the edge on both sides has been enhanced ,so that the edge seems thick and bright. The non maximal suppression stage identifies pixel that are local maxima in the direction of the gradient using magnitude and orientation of the pixel. The major orientation of the gradient, either horizontal or vertical is obtained by comparing the individual component, dx and dy which are convolving the smoothed image with the derivative of Gaussian

Edge Detection Operations The gradient magnitude and directional information from the Sobel horizontal and vertical direction masks can be obtained by convolving the respective x and y masks with the image as in equations.

$$Gx = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix}$$

$$Gy = \begin{pmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{pmatrix}$$

$$M = \sqrt{Gx^2 + Gy^2} = |Gx| + |Gy|$$

Feature Extraction

Different features are extracted from the image. By increasing number of extracted features will increase the accuracy of detection. Although Support Vector Machine (SVMs) as classifier directly determine the decision boundaries in the training step and the method can also provide good generalization in high-dimensional input spaces, many researchers reported that feature selection is important for SVMs. In general, the major aims of feature selection for classification are finding a subset of variables that result in more accurate classifiers and constructing more compact models. An amount of variables can be redundant to the classification problem and feature selection can filter out the variables that are unrelated for the model.

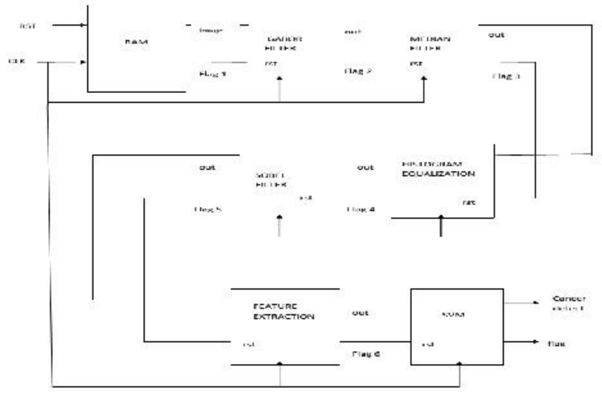
Support vector machines (SVM's) are currently a hot topic in machine learning community and are becoming popular in a wide variety of biological applications. A support vector machine is a computer algorithm that learns by example to assign labels to objects.

Support Vector Machine Based Classification

The SVM classifier is widely used in bioinformatics, due to its high accuracy, ability to deal with high-dimensional data such as genetic factor expression, and edibility in this special context diverse sources of data. The SVM is used in the classification of histopathology images which is often the final goal in image analysis, particularly in cancer applications. The advantage of SVM for its generalization capability. SVM utilizes procedure for reducing the training data points which participates in defining discriminant function. Thus, the participating data points, which are called support vectors, are minimized. Data points which do not participate in defining a classifier are ignored. This can reduce noise and, consequently, can improve the generalization capability. SVM has proved mostly good performance for classification in varied applications, both for real and artificial standard benchmarking data, including applications in medical fields. The problem of experiential data modeling is relevant to many engineering applications.

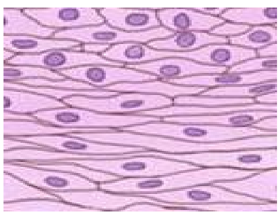
The SVM classifier is widely used in bioinformatics, due to its high accuracy, ability to deal with high-dimensional data such as genetic factor expression, and edibility in this special context diverse sources of data. The SVM is used in the classification of histopathology images which is often the final goal in image analysis, particularly in cancer applications. Features derived from segmented nuclei from histopathology are usually a prerequisite to extracting higher level information regarding the state of the disease.

The Proposed Hardware Architecture

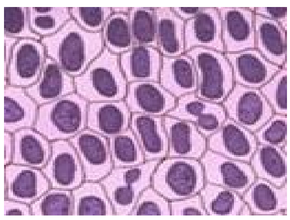


The proposed hardware architecture show how to implement the feature extraction using SVM in hardware. Here the image is stored in RAM memory; from RAM the text file is send to main block where the operation is performed. main block consist of filters, image enhancement block, edge detector, image processing, feature extraction, and SVM.

The filter section consist of gabor and median filter. Gabor filter is used to remove the gaussian noise .median filter used to remove impulse noise. After removing the noise from image it fed into image processing. In image processing histogram equalization is performed. It is used for improve the clarity and partition of pixels in image. It darken the dark pixel and whitesh the white pixel. Output of the histogram is fed into sobel edge detector it helps to improve the edges of image. Sobel out is send to feature extraction, where different features are extracted. by using this features define range by checking with number of image.SVM is used for final image analysis, it check where the image has cancer cell or not.



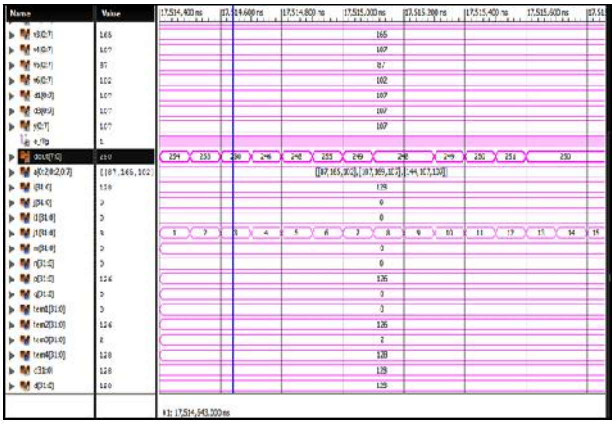
Normal cell

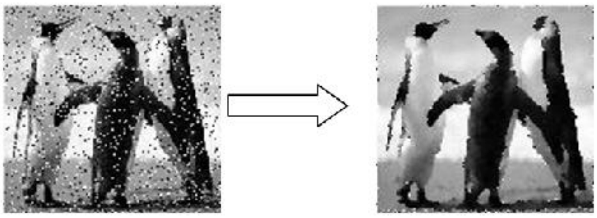


Cancer cell

Simulation results

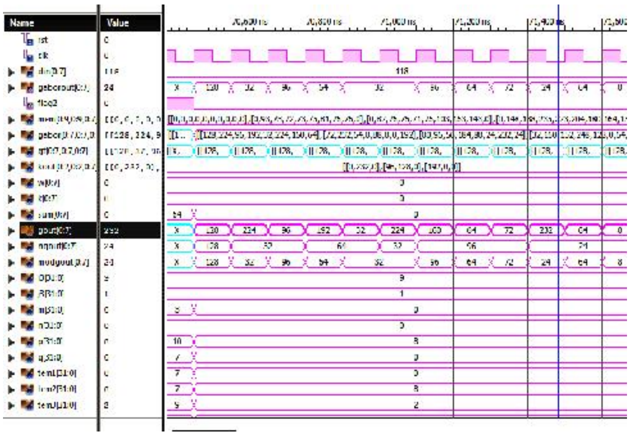
Median filter output



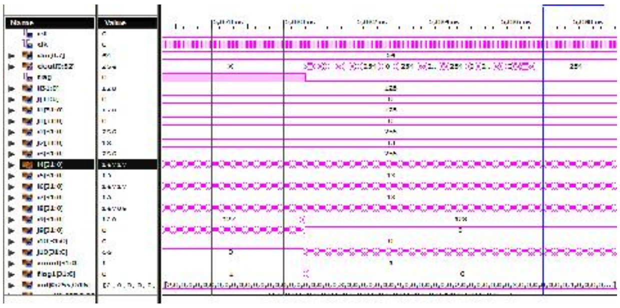


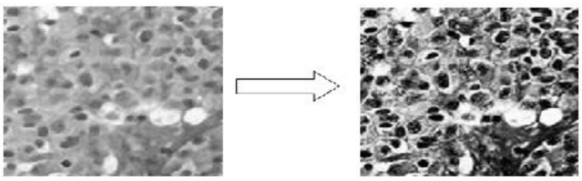
Noise image output of Median filter

Gabor Filter Output



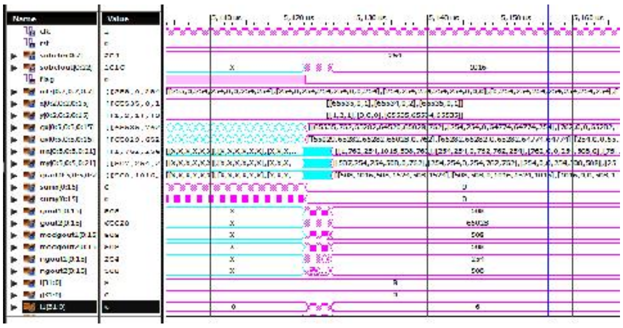
Histogram Equalization Simulation Result



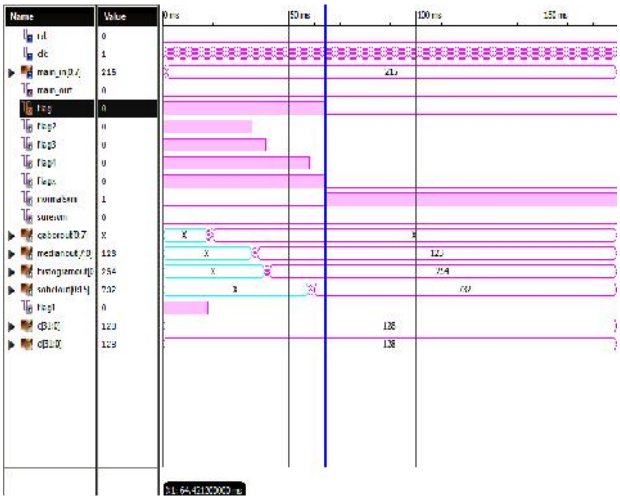


Input image histogram output

Sobel Filter Output



Normal Cell



Cancer Cell Detection

CONCLUSION

SVM has been implemented for classification of benign from malignant skin tumor. Xilinx 14.2 software is used to implement the proposed work and it is conducted on Xilinx Spartan 6 FPGA kit. The features were carried out to generate training and testing of the proposed SVM. This project is a new application based on histo-pathological images of skin lesions that required finding out new features and the correlation of the reduced numbers of features and getting better accuracy. It was required to modify many of the mentioned techniques to make them work for such an application. Concludes that there are some possible factors to improve the accuracy of detecting malignant melanoma by having a higher number of images for training of the SVM network. Future work directions will be to use a hybrid approach of genetic algorithms and Particle Swarm Optimization to improve feature extraction and feature selection.

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